

**RECORDING MEDIUM WITH RESTRICTED PLAYBACK FEATURE AND
APPARATUS AND METHODS FOR FORMING, RECORDING, AND
REPRODUCING THE RECORDING MEDIUM**

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This U.S. nonprovisional application is a continuation of PCT International Application No. PCT/KR2003/001292 filed on July 1, 2003, the entire contents of which are hereby incorporated by reference, which further claims priority on Korean Patent Application No. 10-2002-0037947, filed on July 2, 2002 and Korean Patent Application No. 10-2002-0054762 filed on September 10, 2002, the entire contents of each which are also hereby incorporated by reference.

BACKGROUND OF THE INVENTION

Field of the Invention

[0002] The present invention relates to a recording medium such as BD-ROM (Blu-ray Disc ROM) which has a capability to restrict unauthorized duplication of data written therein, which includes physical mark information and an apparatus and methods for forming, recording, reproducing, and restricting reproduction of illegally duplicated recording media.

Description of the Related Art

[0003] Recently, standardization of new high-density rewritable optical discs has rapidly progressed, for example, BD-RE (Blu-Ray Disc Rewritable), which can store a large quantity of high-quality video and audio data. As a result, products associated with such discs have also been developed. Such products are expected to be commercially available in the near future.

[0004] Referring to Fig. 1, the disc structure of a conventional BD-RE is shown. As shown in Fig. 1, the BD-RE has a center hole and a clamping area which are adapted to allow the optical disc to be loaded in position in an optical disc apparatus. The optical disc also has an information area for recording disc management information and data thereon.

[0005] A lead-in area (LI), a data area, and a lead-out area (LO) are assigned to the information area. A burst cutting area (BCA) is assigned to the area preceding the lead-in area. The BCA, which is not a writable area, contains information modulated into a format unique to BD-RE.

[0006] Referring to Fig. 2, an example of an optical disc apparatus applicable to BD-RE is shown. As shown in Fig. 2, the optical disc apparatus includes an optical pickup 10, a video disc recorder (VDR) system 11, and an encoder 12. The optical disc apparatus performs a data recording operation for encoding and modulating data, externally input thereto, into a format unique to BD-RE, and then recording the modulated data on a data area assigned to the information area of the BD-RE. The optical disc apparatus also performs a data reproduction operation for reading out data recorded on the data area, and processing the read-out data to reproduce original video and audio data.

[0007] The optical disc apparatus having the above-mentioned configuration can record audio/video (A/V) data of a movie or broadcasted program on a BD-RE optical disc 100, and subsequently reproduce the recorded A/V data from the BD-RE optical disc 100 in the form of high-quality video and audio.

[0008] The development and standardization of high-density read-only optical discs, such as BD-RE and its read-only counterpart, BD-ROM (Blu-ray Disc Read-Only Memory), and write-once Blu-ray discs such as BD-R (Blu-ray Disc Recordable) have recently been progressing. However, there is no effective solution for preventing unauthorized duplication of data streams, written on a BD-ROM, or onto other optical discs, such as BD-RE or BD-R.

SUMMARY OF THE INVENTION

[0009] In exemplary embodiments, the present invention is directed to a recording medium, such as a high-density and/or read-only recording medium, such as BD-ROM, capable of preventing unauthorized duplication of data streams, written thereon, onto another medium, such as a BD-RE or BD-R, and to methods and apparatuses for forming, recording, reproducing, and restricting playback of the recording medium to prevent unauthorized duplication.

[0010] In exemplary embodiments, the present invention is directed to a recording medium, such as a high-density and/or read-only recording medium, such as BD-ROM, capable of preventing unauthorized duplication of data streams, written thereon, onto another medium, such as a BD-RE or BD-R, which includes physical mark information and to methods and apparatuses for forming, recording, reproducing, and restricting playback of the recording medium to prevent unauthorized duplication.

[0011] In an exemplary embodiment, the present invention is directed to a recording medium including recorded data, the recording medium including disc identification information identifying the type of

recording medium and a data format of the data on the recording medium to control reproduction of the recorded data.

[0012] In another exemplary embodiment, the present invention is directed to a method of forming a recording medium, including forming disc identification information identifying the type of recording medium and forming the data on the recording medium in a desired data format.

[0013] In another exemplary embodiment, the present invention is directed to a method of reproducing data from a recording medium, including utilizing disc identification information and a data format of the data to control reproduction of the recorded data.

[0014] In another exemplary embodiment, the present invention is directed to a method of recording data on a recording medium, including recording the data in an information area and recording disc identification information in the information area, which controls reproduction of the recorded data.

[0015] In another exemplary embodiment, the present invention is directed to an apparatus for reproducing data from a recording medium, the apparatus utilizing disc identification information and a format of recorded data to control reproduction of the recorded data.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] Features and advantages of the exemplary embodiments of the present invention will become more apparent after reading the following detailed description when taken in conjunction with the

drawings, in which:

Fig. 1 is a diagram illustrating the disc structure of a conventional BD-RE;

Fig. 2 is a schematic block diagram illustrating the configuration of a conventional BD-RE recorder;

Fig. 3 is a diagram illustrating the disc structure of a BD-ROM according to an exemplary embodiment of the present invention;

Fig. 4 is a schematic view illustrating physical disc identification information recorded in the form of a wobbled pit pattern in accordance with an exemplary embodiment of the present invention;

Fig. 5 is a diagram illustrating the disc structure of a BD-R according to an exemplary embodiment of the present invention;

Fig. 6 is a schematic view illustrating physical disc identification information recorded in the form of aligned pit strings in accordance with an exemplary embodiment of the present invention;

Fig. 7 is a table for comparing data recording formats of BD-ROM, BD-RE, BD-R, and BD-R for authoring;

Fig. 8 is a schematic block diagram illustrating the configuration of an optical disc apparatus to which a playback restricting method according to an exemplary embodiment of the present invention is applied; and

Figs. 9a and 9b are flow charts illustrating sequential processes of the playback restricting method carried out in the optical disc apparatus in accordance with an exemplary embodiment of the present invention.

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

[0017] Hereinafter, exemplary embodiments of a recording medium, such as a high-density and/or optical disc according to the present invention, and an apparatus and a method for forming, recording, reproducing, and restricting playback of the high-density optical disc in accordance with the present invention will be described in detail with reference to the attached drawings.

[0018] Referring to Fig. 3, the disc structure of a BD-ROM according to an exemplary embodiment of the present invention is shown. As shown in Fig. 3, the BD-ROM 200 has a center hole and a clamping area which are adapted to allow the BD-ROM 200 to be loaded in position in an optical disc apparatus. The BD-ROM 200 also has an information area on which disc management information and data have been recorded.

[0019] A lead-in area (LI), a data area, and a lead-out area (LO) may be assigned to the information area. A disc identification area, for example, a 'BD-ROM identification (ROMID)' area, can be assigned to the area preceding the lead-in area (LI). The ROMID area may correspond to the BCA of the BD-RE described with reference to Fig. 1. The ROMID area also can be assigned to a particular region of the lead-in (LI) or lead-out area (LO).

[0020] The ROMID area, which is not a writable area, may contain identification information indicating that the associated disc is of a BD-ROM type. This identification information can be modulated and recorded into a format unique to BD-ROM, for example, a physical BD-ROM ID mark.

[0021] As shown in Fig. 4, the physical BD-ROM ID mark can be recorded in the form of a wobbled pit pattern. The physical BD-ROM ID mark

can be detected at an initial stage of a servo operation, independent of a decoding operation for reproducing data. The wobbled pit pattern of the physical BD-ROM ID mark can represent an encryption key value used in encrypting the data to be written on the data area, for example, duplication preventing information.

[0022] Data encoded and modulated into a format unique to BD-ROM is recorded on the data area assigned to the information area. This data is written in a mastering process during the manufacture of the associated disc.

[0023] Fig. 5 illustrates the disc structure of a Blu-ray write-once, that is, BD-R, in accordance with an exemplary embodiment of the present invention. As shown in Fig. 5, the BD-R 300 has a center hole and a clamping area which are adapted to allow the BD-R 300 to be loaded in position in an optical disc apparatus. The BD-R 300 also has an information area for recording disc management information and data thereon.

[0024] A lead-in area (LI), a data area, and a lead-out area (LO) may be assigned to the information area. A disc identification area, for example, a 'BD-R identification (RID)' area, also can be assigned to the area preceding the lead-in area. The RID area may correspond to the BCA of the BD-RE described with reference to Fig. 1.

[0025] The RID area, which is a writable area, may contain identification information representing the fact that the associated disc is of a BD-R type. The identification information can be modulated and recorded into a format unique to BD-R, that is, a physical BD-R ID mark.

[0026] The physical mark can also be recorded in the form of a wobbled

pit pattern, as shown in Fig. 4. The physical BD-R ID mark can be detected at the initial stage of a servo operation, independent of a decoding operation for reproducing data.

[0027] The physical mark can also be recorded in the form of a pit pattern other than the wobbled pit pattern. Using a physical mark having a pit pattern other than the wobbled pit pattern, it is possible to write data on the data area in an encrypted state, and to decrypt the encrypted data read out from the data area. This is described in more detail below.

[0028] Physical mark information, which is recorded on a desired recording area, for example, a lead-in area or a particular area (ROMID or RID area) preceding the lead-in area, in a BD-ROM or a BD-R authored for manufacture of BD-ROM, can be written to have a pattern of repeated mark/space pairs with respect to a monotone high-frequency-modulated (HFM) groove. Each mark/space pair may include a mark and a space each having an optional length.

[0029] For example, as shown in Fig. 6, the physical mark information may be written with respect to a monotone HFM groove in which every recording field having a length of 36T has either a high level or a low level, irrespective of the data sequence value of the physical mark information. Where the data value of a 36T recording field is "1", a mark/space pair including a mark having a length of 3T (3Tm) and a space having a length of 3T (3Ts) may be repeatedly recorded 6 times in the 36T recording field to form a pattern of 6 aligned mark/space pairs. Where the data value of the 36T recording field is "0", a mark/space pair including a mark having a length of 9T (9Tm) and a space having a length of 9T (9Ts) may be repeatedly recorded

2 times in the 36T recording field to form a pattern of 2 aligned mark/space pairs.

[0030] In the latter case, where the data value of the 36T recording field is "0", a mark having a length of 12T (12Tm), a space having a length of 12T (12Ts), and a mark having a length of 12T (12Tm) may be sequentially recorded in the 36T recording field. In this case, however, errors may occur during a tracking servo operation, because the frequencies of RF and push-pull signals may be lowered due to the 12T length of the marks and space. In another exemplary embodiment, repeated mark/space pairs are recorded each including a mark of 9T (9Tm) and a space of 9T (9Ts) which are capable of maintaining respective RF and push-pull signals at appropriate frequencies.

[0031] Where physical mark information is recorded to have a wobbled pit pattern, as described above with reference to Fig. 4, the wobbled pits can be formed using mastering equipment adapted to manufacture BD-ROMs. However, such wobbled pits cannot be recorded in general disc drivers, for example, BD-R drivers, because the wobbling frequency is beyond the driving frequency band of an actuator used in BD-R drivers. As a result, it is impossible to duplicate BD-ROMs, using BD-R drivers.

[0032] In other words, in a BD-R authored for manufacture of BD-ROM, that is, a BD-R for authoring, it is possible not only to record physical mark information, but also to record essential disc information (DI) to be permanently recorded and maintained in an area, such as a permanent information & control (PIC) data region included in the lead-in area of the BD-R, by applying a recording technique in which repeated mark/space pairs, each including a mark and a space,

each having an optional length, are recorded such that they are aligned with one another, with respect to a monotone HFM groove. On the other hand, recording of data in the writable area of the BD-R is achieved with respect to each typical wobbled groove.

[0033] In the case of BD-ROM, wobbled pits or normal pits can be recorded in the area, such as the PIC region of the BD-ROM, whereas data having the form of general pit strings is recorded in the data recording area of the BD-ROM. Accordingly, optical disc apparatuses can more easily distinguish the type of any optical disc, for example, BD-RE or general BD-R, by referring to a pit string recorded in the form of a unique pattern in an area, such as the PIC region of the optical disc.

[0034] Accordingly, in the case of an optical disc apparatus adapted to play back a BD-ROM or BD-R recorded with the above described physical mark information, for example, a BD-ROM player including an optical pickup 20, a VDP system 21, and a D/A converter 22, as shown in Fig. 8, the BD-ROM player detects and identifies the physical mark information at the initial stage of a typical servo operation thereof carried out when an optical disc is loaded, detects and identifies the unique format of data read out from the data area of the optical disc during a data reproduction operation thereof, thereby determining whether or not the data was illegally duplicated on the optical disc, so as to perform a playback restricting operation by stopping playback of the optical disc in accordance with the result of the determination. These operations will be described in detail hereinafter.

[0035] Figs. 9a and 9b are flow charts illustrating a method for

restricting playback of an optical disc in an optical disc apparatus in accordance with an exemplary embodiment of the present invention.

[0036] In the optical disc apparatus shown in Fig. 8, a typical focusing and tracking servo operation is carried out by the VDP system 21 when an optical disc is loaded in the optical disc apparatus (S10), as shown in Fig. 9a.

[0037] At the initial stage of the servo operation, the VDP system 21 accesses a disc identification area preceding a lead-in area, in the data area, in the lead-out area, or in an area following the lead-out area of the information area of the optical disc, to detect and identify physical mark information recorded in the disc identification area. For example, where it is determined that the physical mark information corresponds to ID information associated with BD-ROM (S11), the VDP system 21 determines that the loaded optical disc is a BD-ROM.

[0038] Subsequently, the VDP system 21 searches a data area assigned to an information area of the optical disc, and performs a data reproduction operation for reading out data recorded in the data area, and reproducing the read-out data (S12). Where the data read out in the above described procedure has a format unique to BD-ROM, that is, the read-out data is BD-ROM format data (S13), the VDP system 21 determines the loaded disc to be a normal BD-ROM, and continues the data reproduction (playback) operation (S14).

[0039] On the other hand, where the read-out data does not have the format unique to BD-ROM, that is, it is not BD-ROM format data, the VDP system 21 determines that there is an error in determining the type of the optical disc (S15). In this case, the VDP system 21 stops

the data reproduction (playback) operation or performs the disc determining operation again.

[0040] Where the physical mark information recorded in the disc identification area does not correspond to BD-ROM ID information, for example, where information recorded in accordance with a format unique to BD-RE is detected (S20), the VDP system determines the loaded optical disc to be BD-RE.

[0041] The VDP system 21 searches the data area assigned to the information area, and then performs a data reproduction operation for reading out data recorded in the data area, and reproduces the read-out data (S21). Where the data read out has a format unique to BD-RE, that is, the read-out data is BD-RE format data (S22), the VDP system 21 determines the loaded optical disc to be a normal BD-RE, and continues the data reproduction (playback) operation (S23).

[0042] On the other hand, where the read-out data does not have the format unique to BD-RE, for example, where it is BD-ROM format data, the VDP system 21 determines that BD-ROM data was illegally duplicated on a BD-RE, and displays a report message, while performing a playback restricting operation to stop the data reproduction operation (S24).

[0043] Where BD-R ID information is detected from the physical mark information recorded in the disc identification area (S30), the VDP system 21 determines the loaded optical disc to be BD-R. In this case, the VDP system 21 searches the data area assigned to the information area, and then performs a data reproduction operation for reading out data recorded in the data area, and reproducing the read-out data (S31).

[0044] Where it is subsequently determined that the data read out has

a format unique to BD-ROM, that is, the read-out data is BD-ROM format data (S32), the VDP system 21 determines that BD-ROM data was illegally duplicated on a BD-R, and displays a report message, while performing a playback restricting operation to stop the data reproduction operation (S33).

[0045] On the other hand, where the read-out data does not have the format unique to BD-ROM, for example, where it is BD-RE format data or BD-R format data, the VDP system 21 determines that the loaded optical disc is a normal BD-R, and continues the data reproduction operation (S34).

[0046] Further, although BD-ROM format data is recorded in the data area of a BD-R disc, separate copyright allowance information may additionally be recorded, and a normal data reproduction operation can be carried out if it can be determined that duplication of data was authorized, based on the copyright allowance information.

[0047] As apparent from the above description, exemplary embodiments of the present invention provide a high-density, optical disc, such as BD-ROM, capable of preventing unauthorized duplication of data streams, written thereon, onto a BD-RE or BD-R, and a method for restricting playback of high-density optical discs duplicated illegally in an optical disc apparatus.

[0048] Although the exemplary embodiments of the invention have been disclosed for illustrative purposes, those skilled in the art will appreciate that various modifications, additions and substitutions are possible, without departing from the scope and spirit of the invention as disclosed in the accompanying claims.